# HIGH PERFORMANCE DIRECT-ITERATIVE HYBRID LINEAR SOLUTION METHOD FOR LARGE SCALE STRUCTURAL ANALYSIS

Seung Jo Kim[1)] and Min Ki Kim[1)]

*1) Mechanical Aerospace Engineering, Seoul National University, Seoul 151-742, KOREA*

Corresponding Author : Seung Jo Kim, sjkim@snu.ac.kr

## ABSTRACT

In this paper, hybrid direct-iterative linear solution method is proposed to solve large-scale structural analysis problem. Direct solution method is common to finite element structural analysis, but it has some disadvantage compared with iterative method. Iterative method is quite good performance to solve large scale problem, so we can combine both two method to get good performance to solve the structural analysis problem. Hybrid method proposed in this paper is based on FETI-DP method which is a kind of iterative substructuring domain decomposition method. Whole problem domain is divided into some piece of subdomains and each internal domain is solved by multifrontal direct method and interface variables are treated by iterative solution method. We will show good result and performance point of view convergence speed by proposed method.

## INTRODUCTION

High performance direct-iterative hybrid linear solver for large scale finite element problem is developed. Direct solution method is robust but difficult to parallelize, whereas iterative solution method is opposite for direct method. Therefore hybrid solution method is required to archive both good parallel speedup and numerical robustness by take advantage of two solution methods. Direct solution methods are preferred to the commercial FEM software rather than iterative methods because they have numerical robustness and guarantee to obtain solution various complex problems without concerning of convergence. However, demand of iterative solution methods is growing up with high performance computing and needs of high-fidelity large scale structural analysis problems. Direct solution methods require huge amount of computations and memory space for large scale problems which have millions of DOF (degree of freedom). Moreover, direct solution methods are severely weak for parallel computing compared with iterative methods.

Although iterative solvers have good parallel efficiency, they are influenced by characteristics of problems, or subdomain, total problem size and its ratio. So they often converge very slowly or even fail to converge unless good preconditioner. Therefore hybrid concept of direct method and iterative method should be considered to get accurate solution with both numerical robustness and parallel efficiency[1].

Our structural analysis code, IPSAP has multifrontal solver which is best direct solver points of view computation and memory requirements, and parallel speedup[2]. So best performance direct solver is suitable for domain decomposition based iterative methods, internal subdomain solver is direct method and interface variables (flux or reaction

force) are treated by iterative solution method. In this work, we blend our multifrontal solver into FETI-DP based iterative solver.

The FETI method is a kind of iterative substructuring domain decomposition method. FETI type substructuring methods introduce Lagrange multiplier to enforce the continuity of subdomain interface. Physical meaning of multiplier is reaction force or flux between two substructures. The most important thing is that FETI method has numerical scalability if ratio between subdomain size and global domain size $H/h$ is kept constant[3]. In other words, convergence rate is nearly independent of the problem size. FETI-DP takes advantages of original FETI method and gets rid of difficulties to handle floating substructure mode arising from FETI and FETI-2 methods. The original FETI and FETI-2 methods make effort to treat rigid body modes of substructures, whereas FETI-DP method can avoid this problem simply by introducing corner DOFs[4].

We combine multifrontal solver we developed into FETI-DP based iterative solver. Developed solver will be implemented our general structural analysis code, IPSAP. Developed solver will be tested on the single and multiple processors, called PEGASUS cluster system we have. We will demonstrate large scale structural analysis problem, which is 2 million DOFs problem in single machine and 10 million DOFs problem in parallel machine. Hybrid solution method will be proven to be efficient for large scale problems compared to direct solvers both on single and multi processor systems.

## REFERENCE


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